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AUTHOR: Shakhbazyan, V. A.

TITLE: Infrared Catastrophe in Scalar Quantum Electrodynamics

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 2(8), pp. 484 - 490

TEXT: While a method for the study of the asymptotic behavior in the infrared in spinor electrodynamics has been treated many times before, there occurs an additional difficulty in the electrodynamics of spin-zero particles which is connected with the impossibility of taking into account the four-boson interaction. The author has shown in two previous papers (Refs. 5,6) that the group of the multiplicative renormalizations in scalar electrodynamics have two charge invariants. In the infrared, the photon propagation function is regular, and the charge invariant, which describes the electromagnetic interaction, is a constant (See Ref. 2). The situation is essentially more complicated for the four-boson interaction. L. P. Gor'kov (Ref. 7) has shown already that the Green function of the scalar meson has an infrared singularity. The author of the present

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paper now investigates the asymptotic behavior of the four-vertex function of the spin-zero particle in the infrared. The method is based on the Feynman graph technique. Out of the graphs with four meson ends, only those are concerned in the investigation of the infrared singularity of the matrix structure considered which are shown in Fig. 1. It is first shown that the scalar four-meson function $\square_1$ has a logarithmic singularity when the squares of the external momenta tend to m^2. It is significant that $\square_1$ depends on h and, therefore, the behavior of the second charge invariant $hd_M^2\square_1$ in the infrared has to be taken into account. (d_M - Green's function for the scalar meson). Later the author derives the functional and differential equations for the determination of the asymptotic behavior of the function $\square_1$ in infrared, and discusses the possibilities of solving them by perturbation theoretical methods. In the last part of the work the author discusses a procedure of removing the infrared divergences and summation of the probabilities for charged meson-meson scattering involving the emission of an arbitrary number of

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soft quanta. In order to eliminate the infrared catastrophe in the low orders of perturbation theory, the author uses the method of generalizing the probability graphs, suggested by A. A. Abrikosov. The three sets of graphs which are relevant to the case considered here are represented in Figs. 2-4. The author thanks D. V. Shirkov for guidance, and I. F. Ginzburg, L. P. Gor'kov, and L. D. Solov'yev for discussions. There are 4 figures and 8 Soviet references.

ASSOCIATION: Matematicheskiy institut Akademii nauk SSSR (Mathematics Institute of the Academy of Sciences of the USSR)

SUBMITTED: March 24, 1960

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S/022/61/014/002/005/008
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24,2500 (1191, 1395, 1482)

AUTHOR: Shakhbazyan, V. A.

TITLE: Radiative corrections of lowest orders in scalar quantum electrodynamics

PERIODICAL: Izvestiya Akademii nauk Armyanskoy SSR. Seriya fiziko-matematicheskikh nauk, v. 14, no. 2, 1961, 79-89

TEXT: The present paper contains formulas of radiative corrections of lowest orders to the Green functions of the meson and the photon, which are valid for the entire domain of the argument (here, the momentum), and presents a calculation of the doubly-logarithmic ultraviolet asymptotic behavior of the vertex part of the order of e^2 and of the infrared asymptotic behavior of the four-vertex function Ξ_1. The whole investigation is performed in the Duffin-Kemmer formalism. Using the methods elaborated by N. N. Bogolyubov and D. V. Shirkov (Vvedeniye v teoriyu kvantovannykh poley. GITTL. M. 1957 (Introduction into the theory of quantized fields)) one obtains the following relation in second perturbation-theoretical approximation:

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$$\Sigma_{M}^{(2)}(p) = -\frac{3e^2}{8\pi^2} X \frac{M^2}{m} + \left(\frac{3e^2}{64\pi^2} - \frac{e^2 d_l^0}{64\pi^2}\right) \ln\left(\frac{M}{m}\right)^2 (\hat{p} - m) +$$
$$+ \left(\frac{5e^2}{64\pi^2} + \frac{e^2 d_l^0}{64\pi^2}\right) m \ln\left(\frac{M}{m}\right)^2 - \frac{3e^2(d_l^0 - 1)}{64\pi^2} \ln\left(\frac{M}{m}\right)^2 \left(\frac{p^2 - m^2}{m}\right) X +$$
$$+ \frac{e^2}{64\pi^2}\left\{ -2\frac{p^2 - m^2}{m^2}\left(\hat{p}\frac{p^2 + m^2}{p^2} + 2m\right) A(p) - 2\frac{p^2 - m^2}{p^2}\hat{p} + \right.$$
$$+ \left[\hat{p} - m + \frac{3X}{m}(p^2 - m^2)\right]\frac{p^2 - m^2}{m^2}\left(\frac{p^2 + m^2}{p^2} A(p) + \frac{m^2}{p^2}\right)(d_l^0 - 1) +$$
$$+ 4m\frac{\hat{p}^2}{p^2}\cdot\frac{p^2 - m^2}{p^2}[A(p) + 1](d_l^0 - 1) +$$
$$\left. + \left[2m\frac{\hat{p}^2}{m^2}\cdot\frac{p^2 - m^2}{p^2} - \frac{2}{m}(\hat{p}^2 - m^2)\right](d_l^0 - 1)\right\}, \qquad (1.1)$$

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$$A(p)=\begin{cases}\frac{m^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right|, & |p^2-m^2|\gg\lambda_0^2,\\ \frac{1}{2}\ln\frac{\lambda_0^2}{m^2}, & p^2=m^2,\end{cases}$$

λ_o stands for the fictious mass of the photon introduced for the purpose of eliminating the infrared divergence. The expression for A(p) is accurate up to the imaginary part. By determining the arbitrary constants from the conditions for the vanishing of the radiative corrections to the outer lines, one obtains a definite expression for $\Sigma(p)$. With the aid of the total Green function of the meson: $G(p) = \Delta^c(p) + \Delta^c(p)\Sigma(p)G(p)$ (1.2) one obtains

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$$G_{(2)}(p)=\frac{1}{m}\frac{m^2a_{(2)}(p)+(\hat{p}^2-p^2)b_{(2)}(p)+m\hat{p}d_M^{(2)}(p)}{m^2-p^2}-$$

$$-\frac{1}{m}Y\varphi_{(2)}(p). \qquad (1.3)$$

for $G_{(2)}(p)$ with

$$a_{(2)}(p)=1+\frac{e^2}{64\pi^2}\left[\left(4\frac{p^2-m^2}{p^2}-4\frac{m^2}{p^2}-12\right)\ln\left|\frac{p^2-m^2}{m^2}\right|+\right.$$

$$+\left(4\frac{p^4-m^4}{p^4}+4\frac{m^2}{p^2}\cdot\frac{p^2+m^2}{p^2}\right)\ln\left|\frac{p^2-m^2}{m^2}\right|(d_l^0-1)+ \qquad (1.4)$$

$$+4\frac{p^2-m^2}{p^2}(d_l^0-1)+4\frac{p^2+m^2}{p^2}(d_l^0-1)+$$

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$$+ 2\frac{p^2+m^2}{p^2}(d_l^0-1)+2(d_l^0-1)\Big].$$

$$b_{(2)}(p) = 1 + \frac{e^2}{64\pi^2}\Big[-4\frac{m^2-p^2}{p^2}\cdot\frac{m^2+p^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right| -$$
$$-16\frac{m^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right| + 4\left(\frac{p^2-m^2}{p^2}\cdot\frac{p^2+m^2}{p^2}+\right.$$
$$\left.+\frac{m^4}{p^4}\cdot\frac{p^2+m^2}{p^2}\right)\ln\left|\frac{p^2-m^2}{m^2}\right|(d_l^0-1)+ \qquad (1.5)$$
$$+4\left(\frac{p^2-m^2}{p^2}+\frac{m^2}{p^2}\cdot\frac{p^2+m^2}{p^2}\right)(d_l^0-1)+2\frac{p^2+m^2}{p^2}(d_l^0-1)+$$
$$+8(3-d_l^0)A(m^2)+4(4-3d_l^0)\Big].$$

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$$d_M^{(2)}(p) = 1 + \frac{e^2}{64\pi^2}\left[-2\left(\frac{p^2+m^2}{p^2}\right)^2 \ln\left|\frac{p^2-m^2}{m^2}\right| - 8\frac{m^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right| - \right.$$

$$-2\frac{p^2+m^2}{p^2} + 4\frac{p^2-m^2}{p^2}\cdot\frac{p^2+m^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right|(d_l^0-1) + \quad (1.6)$$

$$+8\frac{m^4}{p^4}\ln\left|\frac{p^2-m^2}{m^2}\right|(d_l^0-1) + \left(4\frac{p^2-m^2}{p^2} + 8\frac{m^2}{p^2}\right)(d_l^0-1) +$$

$$\left. +8(3-d_l^0)A(m^2) + 4(3-d_l^0)\right],$$

and

$$\varphi_{(2)}(p) = \frac{3e^2}{64\pi^2}\left[\frac{p^2-m^2}{p^2}\left(\frac{p^2+m^2}{p^2}\ln\left|\frac{p^2-m^2}{m^2}\right| + 1\right)\right](d_l^0-1). \quad (1.7)$$

Eq. (1.3) is accurate up to third-order terms with respect to e. For $p^2 \gg m^2$ one obtains easily the expressions previously derived by the author for $a_{(2)}(p)$, $b_{(2)}(p)$, $d_M^{(2)}(p)$, and φ.

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$$a_{(2)}(p) = b_{(2)}(p) = d_M^{(2)}(p) = 1 + \frac{e^2}{8\pi^2}(d_l^0 - 3)\ln\left|\frac{p^2 - m^2}{m^2}\right|, \quad (1.8)$$

$$\varphi_{(2)}(p) \to 0.$$

is valid in the infrared range, i.e., for $p^2 \to m^2$. Analogously, the following relation is obtained for the transverse Green function of the photon: $D^{C\,mn}_{tr}(k) = -\frac{d(k^2)}{k^2}\left(g^{mn} - \frac{k^m k^n}{k^2}\right)$ (1.9), and $d_{(2)}(k^2) = 1 + \frac{e^2}{16\pi^2} I(k^2)$ (1.10) with

$$I(k^2) = \int_0^1 dx\,[4x(1-x) - 1]\ln\left|\frac{m^2 - x(1-x)k^2}{m^2}\right|. \quad (1.11)$$

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holds with an accuracy up to the term $\sim e^4$. Based on the same considerations made in the well-known book by Bogolyubov and Shirkov, one arrives at the following parametric representation of the Green function of the photon:

$$D^{C_{mn}}_{(2)_{tr}}(k) = -\left(g^{mn} - \frac{k^m k^n}{k^2}\right)\left\{\frac{1}{k^2 + i\varepsilon} + \frac{e^2}{48\pi^2}\int_{4m^2}^{\infty} dM^2 \frac{(1 - 4m^2/M^2)^{1/2}}{M^2(M^2 - k^2 + i\varepsilon)}\right\}. \quad (1.12)$$

and $d(k^2) = 1 + \frac{e^2}{48\pi^2}\ln\left|\frac{k^2}{m^2}\right| + \dots$ (1.13) holds for $|k^2| \gg m^2$. The second part of the present paper deals with radiative corrections to the vertex parts of Γ and Γ. In calculating them, finite integrations cannot be dispensed with. The author therefore confines himself to calculating the doubly-logarithmic asymptotic behavior of the function Γ_1 in the lowest approximations with respect to e^2 and h. Methods for the determination of the doubly-logarithmic asymptotic behavior of the vertex

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part of the order of e^2 have been devised by V. V. Sudakov (ZhETF, 30, 1956, 87). The method worked out by the latter for the calculation of the type integral is applied in quantum electrodynamics without any alteration; a difference will occur only in the investigation of the matrix structures. The type integral then acquires the form

$$J = \int \frac{d^4k'}{[(p-k')^2 + i\varepsilon][(q-k')^2 + i\varepsilon](k'^2 + i\varepsilon)} \quad (2.1),$$

and for $|k^2| \sim |pq| \gg |q^2|, \ |p^2| \gg m^2$ (2.2) the asymptotic behavior takes the form $J = -\frac{i}{8pq} \ln\left|\frac{pq}{q^2}\right| \ln\left|\frac{pq}{p^2}\right|$ (2.3). The definite expression for the vertex operator of second order reads

$$\Gamma^n_{(2)}(p, q, k) = \Gamma^n\left(1 - \frac{e^2}{32\pi^2}\ln\left|\frac{k^2}{p^2}\right|\ln\left|\frac{k^2}{q^2}\right|\right) - \frac{e^2}{32\pi^2}\frac{p^n + q^n}{m} X \ln\left|\frac{k^2}{p^2}\right|\ln\left|\frac{k^2}{q^2}\right|. \quad (2.4)$$

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An infrared asymptotic behavior of the function D_1 exists if the squares of the external momenta tend toward m^2. It is evident that the behavior of the graphs with infrared singularities is essential in this connection. The radiation operators of fourth order for the scattering of particles of equal sign have the form

$$\frac{1}{S_0}\left\langle \frac{\delta^4 S_{he^2}}{\delta\overline{\psi}_4(p')\,\delta\overline{\psi}_4(q')\,\delta\psi_4(-p)\,\delta\psi_4(-q)}\right\rangle_0 = -\frac{he^2}{(2\pi)^8}\left\{\frac{1}{2}\sum_{(p_1,p_2)=(p',q'),(q',p')}^{(q,p),(p,q)} J^{(1)}_{he^2}(p_1,p_2) + \sum_{(p_1,p_2)=(q',q),(q',p)}^{(p',q),(p',p)} J^{(2)}_{he^2}(p_1,p_2)\right\}\delta(p'+q'-p-q). \quad (2.5)$$

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$$\frac{1}{S_0}\left\langle \frac{\delta^4 (S_{e^4}^{(1)} + S_{e^4}^{(2)})}{\delta\overline{\psi_4}(p')\,\delta\overline{\psi_4}(q')\,\delta\psi_4(-p)\,\delta\psi_4(-q)}\right\rangle_0 = \frac{e^4\delta(p'+q'-p-q)}{4(2\pi)^8}\times$$

$$\times\left\{\sum_{(p_1,p_2,p_3)=(p',q',p'-p),(p',q',p'-q)}^{(q',p',q'-p),(q',p',q'-q)} J_{e^4}^{(1)}(p_1,p_2,p_3) + \right.$$

$$\left. + \sum_{(p_1,p_2,p_3)=(p',q',p'-p),(p',p,p'-q)}^{(q,q',q'-p),(q',p,q'-q)} J_{e^4}^{(2)}(p_1,p_2,p_3)\right\}. \qquad (2.6)$$

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$$J_{he^2}^{(1)}(p_1,p_2) = \int (p_1-k)(p_2+k)\,D^c(p_1-k)\,D^c(p_2+k)\,D_0^c(k)\,d^4k, \qquad (2.7)$$

$$J_{he^2}^{(2)}(p_1,p_2) = \int (p_1-k)(p_2-k)\,D^c(p_1-k)\,D^c(p_2-k)\,D_0^c(k)\,d^4k, \qquad (2.8)$$

$$J_{e^4}^{(1)}(p_1,p_2,p_3) = \int\Big\{4m^2 - 3(p_1-k)^2 - 3(p_2+k)^2 +$$

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$$\frac{1}{m^2}\left[2(p_1-k)^2(p_2+k)^2+[(p_1-k)(p_2+k)]^2\right]\Big\}\times$$
$$\times D^c(p_1-k)\,D^c(p_2+k)\,D_0^c(p_3-k)\,D_0^c(k)\,d^4k, \qquad (2.9)$$
$$J_{e^4}^{(2)}(p_1,p_2,p_3)=\int\Big\{4m^2-3(p_1-k)^2-3(p_2-k)^2+$$
$$+\frac{1}{m^2}\left[2(p_1-k)^2(p_2-k)^2+[(p_1-k)(p_2-k)]^2\right]\Big\}\times$$
$$\times D^c(p_1-k)\,D^c(p_2-k)\,D_0^c(p_3-k)\,D_2^c(k)\,d^4k, \qquad (2.10)$$

The elements of the S-matrix having the structure $X_{\alpha\beta}X_{\gamma\delta}$ and corresponding to the graphs 1b, 1c, and 1d (Fig. 1) are indicated by S_{he^2}, $S^{(1)}_{e^4}$, $S^{(2)}_{e^4}$ (α, β, γ, δ = 0, 1, 2, 3, 4). D^c denotes the causal function of the

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meson within the Klein-Gordon formalism, and D_0^c stands for the Green function of the photon. The usual calibration $d_1^o = 1$ is used. In (2.5) and (2.6) summation is performed over the momentum groups given above; p,q are the initial momenta of the particles, and p',q' are their final momenta. The problem is to find the behavior of the integrals (2.7) - (2.10) for $p^2, q^2, q'^2, p'^2 \to m^2$ simultaneously in the neighborhood of $k \sim 0$. Omitting all small terms in the numerators integrals of the types $\int \frac{d^4k}{(2p_1k-\alpha^2)(2p_2k+\alpha^2)k^2}$, $\alpha^2 = p^2 - m^2$, $k^2 = (k^o)^2 - \vec{k}^2$, $\int \frac{d^4k}{(2p_1k-\alpha^2)(2p_2k-\alpha^2)k^2}$, $p^2 = q'^2 = q^2 = p'^2 \to m^2$ must be estimated in order to determine the infrared asymptotic behavior of integrals (2.7) - (2.10). By evaluating these integrals in the neighborhood of $k \sim 0$ one obtains the following for $\square_1^{(2)}$:

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$$\square_1^{(2)}\left(\frac{p^2-m^2}{m^2}, s_1, s_2, s_3, e^2, h\right) = 1 + \left[e^2 f_1(s_1, s_2, s_3) + \right.$$
$$\left. + \frac{e^4}{h} f_2(s_1, s_2, s_3)\right] \ln\frac{p^2-m^2}{m^2}; \quad (2.11)$$

with

$$f_1(s_1, s_2, s_3) = \frac{1}{4\pi^2}\left\{-\frac{s_1-1/2}{\sqrt{s_1(s_1-1)}}\ln\frac{1+\sqrt{(s_1-1)/s_1}}{1-\sqrt{(s_1-1)/s_1}} + \right.$$
$$+\frac{|s_2|+1/2}{\sqrt{|s_2|(1+|s_2|)}}\ln\frac{1+\sqrt{|s_2|/(1+|s_2|)}}{1-\sqrt{|s_2|/(1+|s_2|)}} + \quad (2.12)$$
$$\left. +\frac{|s_3|+1/2}{\sqrt{|s_3|(1+|s_3|)}}\ln\frac{1+\sqrt{|s_3|/(1+|s_3|)}}{1-\sqrt{|s_3|/(1+|s_3|)}}\right\},$$

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$$f_2(s_1, s_2, s_3) = \frac{1}{16\pi^2}\left\{-\frac{(s_1 - {}^1/_2)^2}{\sqrt{s_1(s_1-1)}} \cdot \frac{s_2+s_3}{4s_2 \cdot s_3} \ln\frac{1+\sqrt{(s_1-1)/s_1}}{1-\sqrt{(s_1-1)/s_1}} + \right.$$

$$+ \frac{(|s_2| + {}^1/_2)^2}{4s_3\sqrt{|s_2|(1+|s_2|)}} \ln\frac{1+\sqrt{|s_2|/(1+|s_2|)}}{1-\sqrt{|s_2|/(1+|s_2|)}} + \qquad (2.13)$$

$$\left. + \frac{(|s_3| + {}^1/_2)^2}{4s_2\sqrt{|s_3|(1+|s_3|)}} \ln\frac{1+\sqrt{|s_3|/(1+|s_3|)}}{1-\sqrt{|s_3|/(1+|s_3|)}}\right\},$$

$$s_1 = \frac{(p+q)^2}{4m^2}, \quad s_2 = \frac{(p'-p)^2}{4m^2}, \quad s_3 = \frac{(p'-q)^2}{4m^2}, \qquad (2.14)$$

$$s_1 + s_2 + s_3 = 1, \quad s_1 > 1, \quad s_2 < 0, \quad s_3 < 0. \qquad (2.15)$$

By exchanging $s_1 \leftrightarrows s_3$, $s_2 \to s_2$ in (2.11) - (2.13) one obtains the expression $\square_1^{(2)}$ for the scattering of particles of opposite charges. In

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scalar electrodynamics one has two generalized Ward identities, the first of which has the same form as the Ward identities of spinorial electrodynamics. The third part of the present paper deals with the determination of the second generlized Ward identity between the vertex part and the Compton part:

$$\sum_l g^{ll} k'^l K^{ml}_{n+2}(p', p, k, k') + \sum_l g^{ll} k'^l K^{lm}_{n+2}(p', p, k', k) = \\ = \Gamma^m_{n+1}(p', p' - k) - \Gamma^m_{n+1}(p' + k', p), \quad (3.5)$$

(3.5).

$$K^{ml}_{n+2}(p', p, k, k') = K^{ml}_{n+2}(p, -p'|k, -k'),$$

$$K^{lm}_{n+2}(p', p, k', k) = K^{lm}_{n+2}(p, -p'|-k', k),$$

$$\Gamma^m_{n+1}(p', p - k') = \Gamma^m_{n+1}(p - k', -p'|k),$$

$$\Gamma^m_{n+1}(p' + k', p) = \Gamma^m_{n+1}(p, -p' - k'|k).$$

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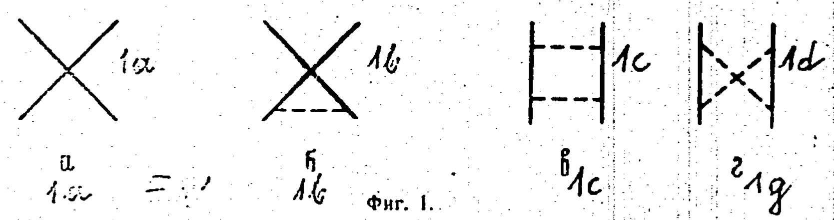
D. V. Shirkov is thanked for guidance. There are 1 figure and 13 references: 11 Soviet-bloc and 2 non-Soviet-bloc.

ASSOCIATION: Matematicheskiy institut im. V. A. Steklova AN SSSR (Institute of Mathematics imeni V. A. Steklov of the AS USSR)

SUBMITTED: June 24, 1960

Fig 1



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24,2500(1136,1144,1482)

AUTHOR: Shakhbazyan, V. A.

TITLE: On the infrared asymptote to the four-vertex function in scalar electrodynamics

PERIODICAL: Akademiya nauk Armyanskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk, v.14, no.4,1961, 155-159

TEXT: The results of the author's work (Ref. 1: Ob infrakrasnoy katastrofe v skalyarnoy kvantovoy elektrodinamike, ZhETF, 39, 484, 1960) are extended to the case of arbitrary Green's photon function d_1^0. In Ref. 1,it was established that in order to determine the asymptotic behavior of the four-vertex function $\Box_1$ in the infrared region, it is necessary to preliminarily determine the infrared asymptote of the invariant charge $hd_M^2 \Box_1$ which represents four-boson interaction. The second invariant charge was defined in the infrared regions, as a result of which Lee's differential

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equations of the renormalization group could be derived. The final results (in Ref. 1) were obtained, however, for the particular case $d_1^0 = 1$. In order to find the infrared singularity of the four-vertex function with arbitrary d_1^0, an additional term has to be added to the formulas of Ref. 1. In order to determine the infrared singularity of the (Feynman) diagrams 1a, 1b, and 1c (see Fig. 1), for $d_1^0 = 1$, it is necessry to evaluate Feynman integrals of type

$$\int \frac{d^4k}{(2p_1k - \alpha^2)(2p_2k \pm \alpha^2)k^2} \qquad \text{(a)}$$

where $\alpha^2 = p^2 - m^2$, k^2 - is the square of the four-momentum of external particles, m - the meson mass, $\alpha^2 \to 0$. In the case of arbi-

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On the infrared asymptote ...

trary d_1^0, integrals of type

$$\int \frac{(p_1k)(p_2k)d^4k}{(2p_1k \mp \alpha^2)(2p_2k \pm \alpha^2)k^2}, \quad \int \frac{(p_1k)(p_2k)d^4k}{(2p_1k - \alpha^2)(2p_2k \pm \alpha^2)(k^2)^2} \qquad (b)$$

have to be evaluated. Such an evaluation is difficult for $\alpha^2 \neq 0$. Integral (b) can be evaluated by setting $\alpha^2 = 0$ and by introducing the photon mass λ. Thereupon, diagrams 1a, 1b and 1c are calculated; then the formulas for the function $\square_1$ are obtained (analogous to those of Ref. 1). These formulas apply to the scattering of particles of one sign. For the scattering of particles of the opposite sign, variables have to be interchanged. Asymptotic expression of $\square_1$ for $p^2 \to m^2$. As in Ref. 1, by solving Lee's differential equations, one obtains

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$$\widetilde{\square}_1\left(\frac{x-y}{1-y}, s_i, e^2, h_\alpha\right) = \frac{1}{1-a}\left[\left|\frac{x-y}{1-y}\right|^{e^2 f_1(s_i)} - a\left|\frac{x-y}{1-y}\right|^{(3-d_1^0)\frac{e^2}{8\pi^2}}\right] \quad (2.2)$$

where

$$a = e^2 f_2(s_i)\left\{h_\alpha\left[f_1(s_i) + \frac{d_1^0 - 3}{8\pi^2}\right] + e^2 f_2(s_i)\right\}^{-1} \quad (2.3)$$

30396
S/022/61/014/004/010/010
D299/D302

On the infrared asymptote ...

There are 1 figure and 2 Soviet-bloc references.

ASSOCIATION: Fizicheskiy institut AN Armyanskoy SSR (Institute of Physics AS Armenian SSR)

SUBMITTED: April 15, 1961

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S/022/61/014/004/010/010
D299/D302

On the infrared asymptote ...

Fig. 1

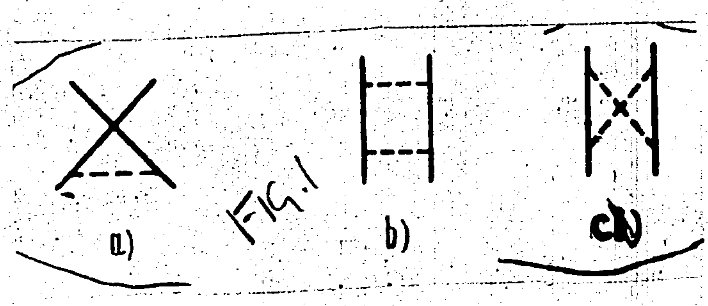

FIG. 1

4

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ARUTYUNAYAN, V.M.; VARTANYAN, Yu.L.; CHUBARYAN, E.V.; SHAKHBAZYAN, V.A.; AMATUNI, A.TS.; DZHRBASHYAN, V.A.; MELIK-BARKHUDAROV, T.K.; TEVIKYAN, R.V.; BERESTETSKIY, V.B., prof., red.; SHTIBEN, R.A., red. izd-va; KAPLANYAN, M.A., tekhn. red.

[Problems in the theory of strong and weak interactions of elementary particles; lectures] Voprosy teorii sil'nykh i slabykh vzaimodeistvii elementarnykh chastits; lektsii. Pod obshchei red. V.B.Berestetskogo. Erevan, Izd-vo Akad. nauk Armianskoi DDR, 1962. 190 p. (MIRA 15:5)

1. Akademiya nauk Armyanskoy SSR. Fizicheskiy institut. (Nuclear reactions)

ALIKHANYAN, A.I., red.; NIKITIN, S.Ya., prof., otv. red.; TER-MARTIROSYAN, K.A., prof., otv. red.; AMATUNI, A.TS., red.; SHARKHATUNYAN, R.O., red.; SHAKHBAZYAN, V.A., red.; SHTIBEN, R.A., red. izd-va; KAPLANYAN, M.A., tekhn. red.

[Problems in the physics of elementary particles]Voprosy fiziki elementarnykh chastits; lektsii, prochitannye na 2. sessii... Pod obshchei red. A.I.Alikhaniana. Erevan, Izd-vo Akad. nauk Armianskoi SSR, 1962. 396 p. (MIRA 16:3)

1. Vesennyaya shkola teoreticheskoy i eksperimental'noy fiziki. 2. sesssiia, Nor-Amberd, 1962. 2. Chlen-korrespondent Akademii nauk SSSR (for Alikhanyan).

(Particles (Nuclear physics))

SHAKHBAZYAN, V.A.

Derivation and solution of a system of integral equations describing the amplitudes of τ^+ and τ'^+ decays of K^+ mesons. Izv. AN Arm.SSR.Ser.fiz.-mat. nauk 16 no.5:107-118 '63. (MIRA 16:11)

SHAKHBAZYAN, V.A.

Integral equation for the $\omega_0 \rightarrow 3\pi$ decay. Zhur. eksper. i teor. fiz. 46 no.1:196-200 Ja'64. (MIRA 17:2)

SHAKHBAZYAN, E.S.

25276 SHAKHBAZYAN, E.S. Petraleksandrovich Gertsen. (Khirurg. 1871-1947). Sbornik Trudov Gospit. Khrurg. Kliniki (Peryy Mosk. Med. In-T). M. 1949, S. 5-13, S. Portr. Bibliogr:(Spisok Nauchnykhtrudov Prof. P. A. Gertsena). S-16-18

SO: Letopis' No. 33, 1949

SHAKHBAZYAN, YE. S.

D'yakonov, Petr Ivanovich, 1855-1908

P. I. D'yakonov, (1855-1908) Fel'd. i akush. no. 9, 1952.

Monthly List of Russian Accessions, Library of Congress, December 1952. Unclassified.

1. E. S. SHAKHBAZIAN

2. USSR (600)

4. Biliary Tract - Diseases

7. Functional diseases of the bile ducia. YE S. Shakhbazian. Klin. med. 30 no. 12. 1952.

9. Monthly List of Russian Accessions, Library of Congress, April 1953, Uncl.

SHAKHBAZYAN, Ye.S., professor

Problems in the surgery of bile ducts. Sov. med. 18 no.12:11-15 D '54. (MLRA 8:2)

1. Iz gospital'noy khirurgicheskoy kliniki imeni A.V.Martynova (zav. prof. V.E.Salishchev) I Moskovskogo ordena Lenina meditsinskogo instituta.

(CHOLECYSTITIS, surgery
indic. & procedure)
(CHOLECYSTOGRAPHY
in cholecystitis surg., importance)

/ Ye.

SHAKHBAZYAN, Ye.S.

[Problems in clinical surgery] Voprosy klinicheskoi khirurgii. Moskva, Medgiz, 1955. 225 p. (MLRA 8:11)
(Surgery)

SHAKHBAZYAN, Ye.S., professor; CHILINGARIDI, Ye.K.

Materials on surgery for cryptorchidism. Khirurgiia no. 12:12-17 D' 55. (MLRA 9:7)

1. Iz gospital'noy khirurgicheskoy kliniki I Moskovskogo ordena Lenina meditsinskogo instituta (zav. prof. V.I.Salishchev)
(TESTES, abnorm.
cryptorchidism, surg.)
(ABNORMALITIES
same)

SHAKHBAZYAN, E. S.

SHAKHBAZYAN, E.S.

[Cryptorchism and its treatment] Kriptorkhizm i ego lechenie. Moskva, Medgiz, 1957. (MIRA 11:1)

(TESTICLE--ABNORMALITIES AND DEFORMITIES)

SHAKHBAZYAN, Ye.S., prof.(Moskva)

Surgical treatment of obliterating endarteritis. Klin.med. 36 no.11:22-30 N'58 (MIRA 11:12)

1. Iz I Moskovskogo ordena Lenina meditsinskogo instituta (dir. - prof. V.V. Kovanov).
(ARTERIOSCLEROSIS, OBLITERANS, surg.
sympathectomy (Rus))
(SYMPATHECTOMY, in various dis.
arteriosclerosis obliterans (Rus))

SHAKHBAZYAN, Ye.S., prof.

Professor Aleksei Martynov; on the 25th anniversary of his death. Khirurgiia 35 no.3:3-8 Mr '59. (MIRA 12:8)
(SURGERY
contribution of Aleksei Martynov (Rus))
(BIOGRAPHIES
Martynov, Aleksei (Rus))

SHAKHBAZYAN, Ye.S., prof. (Moskva)

Drainage of the abdominal cavity in operations on the biliary tract. Klin.med. 40 no.10:70-73 O '62. (MIRA 15:12)
(BILIARY TRACT--SURGERY) (DRAINAGE, SURGICAL)

ABRAMYAN, A.Ya., prof.; BUSALOV, A.A., prof.; VELIKORETSKIY, A.N., prof.; GROZDOV, D.M., prof.; DORMIDONTOVA, K.V., dots.; ZHMAKIN, K.N., prof.; KORNEV, P.G.; LEVIT, V.S.prof. [deceased]; LIKHACHEV, A.G., prof.; LOBACHEV, S.V., prof.; MOLODAYA, Ye.K., prof.; PETROV, B.A.; PRIOROV, N.N.[deceased]; SALISHCHEV, V.E., prof. [deceased]; SAPOZHKOV, P.I., prof. [deceased]; TERNOVSKIY, S.D. [deceased]; FAYERMAN, I.L., prof., zasl. deyatel' nauki; CHAKLIN, V.D.; CHENTSOV, A.G., prof. [deceased]; CHERNAVSKIY, V., prof.; SHADURSKIY, K.S., prof.; SHAKHBAZYAN, Ye.S., prof.; VELIKORETSKIY, A.N., prof., red.; GORELIK, S.L., dots., red.; YELANSKIY, N.N., red.; STRUCHKOVA, V.I., red.; RYBUSHKIN, I.N., red.; BUL'DYAYEV, N.A., tekhn. red.

[Surgeon's manual in two volumes] Spravochnik khirurga v dvukh tomakh. Moskva, Medgiz. Vol.2. 1961. 642 p. (MIRA 17:4)

1. Chlen-korrespondent AMN SSSR (for Yelanskiy, Struchkova, Petrov, Ternovskiy, Chaklin). 2. Deystvitel'nyy chlen AMN SSSR (for Kornev, Priorov).

SHAKHBAZYAN, Ye.S., prof. (Moskva)

"Problems of thoracic and abdominal surgery; "Trudy" of the Saratov State Medical Institute, vol. 33. Reviewed by E.S. Shakhbazian. Klin. med. 41 no.2:152-154 F'63 (MIRA 17:3)

SHAKHBAZYAN, Ye.S., prof. (Moskva)

Professor Aleksei Vsil'evich Martynov; on the 30th anniversary of his death. Khrirugiia 40 no.7:145-148 Jl '64. (MIRA 18:2)

SHAKHBAZYAN, Yu.L.

Investigating the thermoelastic rigidity of plane reflectors of radio telescopes. Izv. GAO 23 no.3:169-179 '64.

Precision of the reflecting surface of a parabolic mirror of a radio telescope subjected to solar heating. Ibid.:180-185

(MIRA 17:11)

SHAKHBAZYAN, Yu.L.

Study of deformations of a nonuniformly heated cylindrical reflector of a radio telescope. Izv. GAO 24 no.1:109-113 '64. (MIRA 18:3)

SHAKHBAZYAN, Z.

Machine for cutting carrots and squash. Prom.Arm. 5 no.2:41 F '62. (MIRA 15:2)

1. Glavnyy inzh. Yerevanskogo konservnogo zavoda.
(Erivan--Canning industry--Equipment and supplies)

SHAKHBAZYAN, Z.

Contest of workers' ingenuity. Prom.Arm. 4 no.12:54-55 D '61. (MIRA 15:2)

1. Glavnyy inzh. Yerevanskogo konservnogo zavoda.
(Erivan--Canning industry--Technological innovations)

IVANOV, V.K.; FISHMAN, G.M.; SHAKHBAZYAN, Z.M.

The Shakhbazyan machine for removing seeds from apricots and plums.
Kons. i ov. prom. 12 no.2:4-7 F '57. (MIRA 10:6)

1. Batumskiy filial Vsesoyuznogo nauchno-issledovatel'skogo instituta konservnoy i ovoshchesushil'noy promyshlennosti (for Ivanov and Fishman).
2. Armyanskiy konservnyy trest. (for Shakhbazyan)
(Canning industry--Equipment and supplies) (Apricot) (Plum)

SHAKHBAZYAN, Z.M.

We are putting into practice what the party planned. Kons. i ov. prom. 16 no.9-10 0 '61. (MIRA 14:11)

1. Yerevanskiy konservnyy zavod.
(Erivan--Canning industry)

SHAKHBAZYAN, Zh. A.

USSR/Cultivated Plants. Potatoes. Vegetables. Melons. M

Abs Jour : Ref Zhur-Biol., No 15, 1958,

Author : Shakhbazyan, Zh. A.
Inst : Armenian Scientific Research Institute of Hydrotechnology and Melioration.
Title : A Tomato Irrigation Regime for the Urban Zone Around Yerevan.

Orig Pub : Tr. Arm. n.-i. in-ta gidrotekhn. i melior., 1957, 2, 171-177

Abstract : In 1954-1955, an investigation was conducted of the irrigation regime of the Ararati 15 tomato variety. Irrigation was performed along long blunt furrows. The best irrigation norm is recognized as 350-375 cubic meters/hectare, distributed as follows: one irrigation between

Card : 1/2

USSR/Cultivated Plants. Potatoes. Vegetables. Melons. M

Abs Jour : Ref Zhur-Biol., No 15, 1958, 68185

transplantation and the formation of ovaries, three irrigations between the formation of ovaries and flowering, two irrigations between flowering and the beginning of fruit formation, and 5 irrigations during the harvesting period. The yield on the experiment plot was almost twice as high as average yields at the sovkhoz. The fruits were larger, with an average weight of 152 g. The water consumption declined by 40-50 percent. -- O. A. Gorbunova

Card : 2/2

57

KOTOV, B.A.; OKUNEVA, N.M.; SHAKH-BUDAGOV, A.L.

Hybrid system of a neutron spectrometer. Fiz. tver. tela 7 no.5:1423-1424 My '65. (MIRA 18:5)

1. Institut poluprovodnikov AN SSSR, Leningrad.

SHAKHBUDAGOV, S.G., zasluzhennyy vrach RSFSR

Work of a consolidated pediatric hospital. Vop. okh. mat. i det. 6 no.9:77-79 S '61. (MIRA 14:9)

1. Glavnyy vrach Ob"yedinennoy detskoy bol'nitsy imeni V. Slutskoy, Leningrad.

(LENINGRAD—CHILDREN—HOSPITALS)

FRENKEL', Ye.B., kand. tekhn. nauk; KHMEL'NITSKAYA, Ye.G., mladshiy nauchnyy sotrudnik; SHAKHET, G.A., inzh.

Moisturing fur skins by steam-air mixture. Leg. prom. 18 no.5:35-36 My '58. (MIRA 11:6)

(Fur--Dressing and dyeing)

SHAROV, N.V.; SHAKHET, G.P.; RAMENOV, A.S.; KUKHAREV, P.P.; KLOCHKOV, S.A., retsenzent; MARTYNOV, S.F., retsenzent; OSIPOV, Ya.I., retsenzent.

[Machinery and apparatus for the fur industry] Mashiny i apparaty mekhovogo proizvodstva. Pod obshchei red. N.V.Sharova. Moskva, Gos. nauchno-tekhn. izd-vo Ministerstva promyshlennykh tovarov shirokogo potrebleniia SSSR, 1953. 358 p. (MLRA 7:6)
(Fur industry)

SHAKHET, Grigoriy Pinkhusovich; KLYAGINA, N.I., red.; SHAROV, N.V., red.; MINAYEVA, T.M., red.; MEDVEDEV, L.Ya., tekhn.red.

[Handbook on the fur and sheepskin industry] Spravochnik po mkhovoi i ovchinno-shubnoi promyshlennosti. Vol.3. [Equipment] Oborudovanie. 1959. 367 p. (MIRA 12:12)
(Hides and skins--Handbooks, manuals, etc.)

SHAKHET, G.P., inzh.; KURLATOVA, L.N., inzh.; BRUSSER, V.M., inzh.

Remodeling of the KS2-100 annular frame dryer. Nauch.-issl. trudy NIIMP no.9:107-116 '59. (MIRA 14:5)
(Drying apparatus)
(Fur industry--Equipment and supplies)

SHAKHET, G.P., inzh.

Continuous PShM1-1200 shearing machine. Nauch.-issl.trudy NIIMP no.10:76-87 '60. (MIRA 14:4)

(Fur--Dressing and dyeing)

FRENKEL', Ye.B.; SHAKHET, G.P.; KAZAS, V.M.; KHMEL'NITSKAYA, Ye.G.; BRUSSER, V.M.; KAS'YANOVA, R.V.

New method of moistening fur skins and cuts in furrier work. (MIRA 16:2)
Kozh.-obuv.prom. 5 no.1:28-31 Ja '63.
(Fur—Dressing and dyeing)

SHAKHFOROSTOVA, N. P.

Spinal Ganglia of the Camel
Tr. Alma-Atinskogo Zoovet. In-ta., No7 , 1953, pp 186-189

The macroscopic appearance and the microscopic structure of the spinal ganglia of the camel were studied. The author found a great number of different-sized cells (gangliomeres) and, based on the fact that in the spinal ganglia multipolar (branching) cells are absent, he concluded that impulses are transmitted to the spinal cord without a change in connections and that the ganglia belong to the peripheral nervous system. (RZhBiol, No 2, 1955)

SO: Sum. No 639, 2 Sep 55

MALAKHOV, Z.S., kapitan 1 ranga zapasa; SHAKHGEDANOV, A.A., inzh.-kapitan 1 ranga; LOPATIN, A.M., kapitan 1 ranga; YEMEL'YANOV, N.V., kapitan 1 ranga; BOGOYAVLENSKIY, D.N., kapitan 2 ranga; GORODENKO, B.K., kapitan 2 ranga; VAL'KOV, I.Ya., inzh.-podpolkovnik; NOVOSIL'TSEV, O.N., kapitan-leytenant, BIRINBERG, M.E., inzh.; FADEYEV, V.G., vitse-admiral, obshchiy red.; MASHAROV, A.I., red.; STREL'NIKOVA, M.A., tekhn.red.

[Practical seamanship] Morskaia praktika. Moskva, Voen.izd-vo M-va obor.SSSR. Pt.1. 1958. 416 p. (MIRA 12:6)
(Navigation)

SHAKHGEDANOV V.B

CA

PROCESSES AND PROPERTIES INDEX

13

Substitutes for metals in machine construction. B. M. Milman and V. B. Shakhgedanov. *Vestnik Standartizatsii* 13, No. 12, 17-19(1938); *Chem. Zentr.* 1939, II, 1962.—Antifriction cast iron or a powder-metallurgical material *Woisite* can be used in place of bronze for bearings. Woisite has a resistance to compression of 10-50 kg./sq. cm., a Brinell hardness of 20-60, an impact resistance (notched bar) of 3 kg./sq. cm., elongation of 3%, resistance to abrasion of 0.0005-0.001 kg./sq. cm., coeff. of friction of 0.005-0.01 and a coeff. of thermal expansion of $11 \times 10^{-6} - 14 \times 10^{-?}$. With liberal lubrication it gives good service. Cast-iron drums of textile machines can be replaced by gypsum drums having a mech. strength of 7-14 kg./sq. cm. 1-7 days after setting. A plastic mass *Faolite* or similar materials are recommended as substitutes for Pb. For Faolite, the resistance to compression is 450-500 kg./sq. cm., tensile strength 200-300 kg./sq. cm., bending strength 450-500 kg./sq. cm. and the Brinell hardness 12-15 at 250 kg. pressure.

M. G. Moore

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

SHAKHGEDANOV, V. B.
Min Higher Education USSR. Moscow Textile Institute, Moscow, 1956

SHAKHGEDANOV, V. B. "Investigation of the curving of a spindle during manufacture and methods of straightening it." Min Higher Education USSR. Moscow Textile Inst. Moscow, 1956.
(Dissertation for the Degree of Candidate in Technical Sciences)

SO: Knizhnaya Letopis', No. 20, 1956.

SHAKHGEDANOV, V.B., inzh.

Straightening rollers and rods. Sbor. st. NIILTEKMASH no.3:63-70 '57. (MIRA 12:10)
(Machine-shop practice)

MIKAELYAN, Andrey Leonovich; SHAKHGEDANOV, V.N., red.; LARIONOV, G.Ye., tekhn. red.

[Theory and applications of ferrites at super-high frequencies] Teoriia i primenenie ferritov na sverkhvysokikh chastotakh. Moskva, Gosenergoizdat, 1963. 662 p. (MIRA 16:3)
(Microwaves) (Wave guides) (Ferrates)

MAMEDALIYEV, Yu.G. [deceased]; BABAKHANOV, R.A.; MAGERRAMOV, M.N.;
SHAKHGEL'DIYEV, M.A.

Alkylation of aromatic compounds with allyl bromide. Dokl.
AN Azerb. SSR 18 no.7:23-26 '62. (MIRA 17:2)

1. Institut neftekhimicheskikh protsessov AN AzSSR.

MAMEDALIYEV, Yu.G. [deceased]; SHAKHGEL'DIYEV, M.A.; BABAKHANOV, R.A.

Reaction of cresols with allyl bromide. Dokl. AN Azerb. SSR 18 no.11:15-16 '62. (MIRA 17:2)

1. Institut neftekhimicheskikh protsessov AN AzSSR.

BABAKHANOV, R.A., MAGERRAMOV, M.N., SHAKHGEL'DIYEV, M.A.

Alkylation of benzene with allyl iodide. Azerb. khim. zhur. no. 2:55-58 '65. (MIRA 18:12)

1. Institut neftekhimicheskikh protsessov AN AzerSSR. Submitted Oct. 20, 1964.

BABAKHANOV, R.A.; MAGERRAMOV, M.N.; SHAKHGEL'DIYEV, M.A.

Alkylation of toluene by allyl iodide. Azerb. khim. zhur. no.3: 53-56 '65. (MIRA 19:1)

1. Institut neftekhimicheskikh protsessov AN AzerSSR i Azerbaydzanskiy gosudarstvennyy universitet im. S.M. Kirova.

SHAKHGEL'DYANTS, A.Ye., nauchnyy sotrudnik

General incidence disease of as shown by visits to physicians and the incidence of disease with temporary disability among workers and employees of industrial enterprises. Zdrav. Ros. Feder. 4 no. 4:11-18 Ap '60. (MIRA 13:10)

1. Iz Instituta organizatsii zdravookhraneniya i istorii meditsiny imeni N.A. Semashko (dir. Ye.D. Ashurkov).
(DISEASE—REPORTING) (DISABILITY EVALUATION)
(MINERS—DISEASE AND HYGIENE)

ALEKSANDROVA, Margarita Borisovna; SHAKHGEL'DYANTS, A.Ye., red.; KOKIN, N.M., tekhn. red.

[Methodology for compound study of morbidity] Metodika kompleksnogo izucheniia zabolevaemosti. Moskva, Medgiz, 1963. 82 p. (MIRA 16:7)
(MEDICAL STATISTICS)(INDUSTRIAL HYGIENE)

APPROVED FOR RELEASE: 07/20/2001 CIA-RDP86-00513R001548530002-3"

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Ispol'zovaniye vnutrennikh rezervov na shelkokrutil'noy fabrike ((Krasnaya krutil'shchitsa)). (M., 1954) 10s. s. cheir. 20 sm. (M-vo prom. tovarov shirokogo potrebleniya SSSR. Tekhn. upr. Otd. tekhn. informatsii. Obmen peredovym opytom). 1,000 ekz. Bespl.--Sost. ukazan v kontse teksta- Bez. tis. L.I. obc.--(54-54657) p 677.4.022 sr.

SO: Knizhnaya, Letopis, Vol. 1, 1955

SHAKHGIL'DYAN, I.V.; MEYER, O.I.

Some problems in the clinical aspects and diagnosis of nonicteric forms and attenuated forms of infectious hepatitis in children. Vop. okh. mat. i det. 6 no.3:61-66 Mr '61. (MIRA 14:10)

1. Iz kliniki (zaveduyushchiy - prof. N.V. Sergeyev) Instituta virusologii imeni D.I.Ivanovskogo AMN SSSR (direktor - prof. P.N. Kosyakov) i infektsionnoy gorodskoy klinicheskoy bol'nitsy No.2 (glavnyy vrach A.M.Pyl'tsova).

(HEPATITIS, INFECTIOUS)

SINAYKO, G.A., kand.med.nauk; SHAKHGIL'DYAN, I.V.

Determination of glutamic-oxalic transaminase activity in Botkin's disease in children. Pediatriia no.5:18-23 '61. (MIRA 14:5)

1. Iz kliniki (zav. - prof. I.V. Sergeyev) Instituta virusologii imeni D.I. Ivanovskogo AMN SSSR (dir. - prof. P.N. Kosyakov) na baze Gorodskoy infektsionnoy klinicheskoy bol'nitsy No.2 (glavnyy vrach A.M. Pyl'tsova).
(HEPATITIS, INFECTIOUS) (TRANSAMINASE)

PAKTORIS, Ye.A.; SHAKHGIL'DYAN, I.V.

Anicteric forms of epidemic hepatitis and their epidemiological significance. Sov.med. 25 no.5:71-78 My '62. (MIRA 15:8)

1. Is Instituta virusologii imeni D.I.Ivanovskogo AMN SSSR (dir. - deystvitel'nyy chlen AMN SSSR prof. V.M.Zhdanov).
(HEPATITIS, INFECTIOUS)

SHAKHGIL'DYAN, I.V., kand.med.nauk

Anicteric form of epidemic hepatitis. Virusy i virus. zabol. no.1:144-167 '64. (MIRA 18:2)

SHAKHGIL'DYAN, I.V.; BRAGINSKIY, D.M.

Importance of determining the activity of serum enzymes in the diagnosis of Botkin's disease in children. Vop.med.virus. no.9: 339-351 '64. (MIRA 18:4)

1. Institut virusologii imeni Ivanovskogo AMN SSSR, Moskva.

CHAKHGIL'DYAN, I.V., kand. med. nauk

Comparative characteristics of the clinical course and outcome in anicteric and icteric forms of Botkin's disease in children. Sov. med. 28 no.10:32-37 O '65. (MIRA 18:11)

1. Klinicheskoye otdeleniye (zav.- dotsent Ye.S. Ketiladze, nauchnyy rukovoditel' - deystvitel'nyy chlen AMN SSSR prof. A.F. Bilibin) Instituta virusologii imeni Ivanovskogo (dir.- deystvitel'nyy chlen AMN SSSR prof. V.M. Zhdanov) AMN SSSR, Moskva.

30139
S/194/61/000/007/069/079
D201/D305

6.4200
9.3278

AUTHORS: Terent'yev, B.P., Shakhgil'dyan, V.V. and Lyakhov-khin, A.A.

TITLE: A UHF radial system of radiocommunication with time division of channels

PERIODICAL: Referativnyy zhurnal. Avtomatika i radioelektronika, no. 7, 1961, 2, abstract 7 K9 (Tr. uchebn. in-tov svyazi, M-vo svyazi SSSR, 1960, no. 3, 51-58)

TEXT: A system is described of radial UHF radio communication as designed in 1957-1958 at the Moscow Electrical and Technical Institute of Communication. This is a multi-channel system with pulse-position modulation. Operating frequency range 400 mc/s. The system is tuned according to the principle of a communication grid i.e. there is a central station (CS) and several exchange stations. Communication between two exchange stations is established by the commutator of the CS. Through it, any exchange station may be con-

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A UHF radial system...

nected to any of the subscribers of the distribution network. The number of channels at CS: 10. Pulse duration: 1 micro second. Cross-talk interchannel attenuation ~ 60 db. The peak transmitter power of the exchange station: 30 kW. The bloc-diagrams and other particulars of the system are given. [Abstracter's note: Complete translation]

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89828

S/106/60/000/011/002/010
A055/033

9.2580
9.3260 (also 1067 only)

AUTHORS: Terent'yev, B.P. and Shakhgil'dyan, V.V.

TITLE: Automatic Phase Control as a Means of Obtaining a Highly Stable Regulated Frequency

PERIODICAL: Elektrosvyaz', 1960, No.11, pp. 15-20

TEXT: Automatic phase control ensures greater stability of a synchronized generator than does automatic frequency control. An automatic phase control system is therefore described in the present article, this system allowing to control the frequency of stable generators within any portion of the frequency range. Interpolation methods of retuning h.f. generators are widely used nowadays. However, in order to suppress effectively the spurious combination-frequency voltages, the systems based upon these methods require the use of a great number of high-quality filter-chains. The automatic phase control system described by the author of the present article eliminates this disadvantage. This new system is shown schematically in Fig. 1. Oscillations from the synchronized generator (frequency ω_0') and from the

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Automatic Phase Control as a Means of Obtaining a Highly Stable Regulated Frequency

standard generator (frequency ω_0) enter into the mixer, at the output of which appears the difference frequency $\Delta\omega = \omega_0' - \omega_0$. The difference frequency voltage is applied to the phase detector, which receives at the same time a voltage (frequency Ω) from the shift-generator. The comparison of the phases of these two voltages takes place in the phase detector, and as a result, a regulating voltage appears at its output. After filtration of spurious oscillations by the low-frequency filter (7), this regulating voltage is applied to the regulating element which produces the correcting detuning. The steady-state (synchronization) conditions are set up in the system when Ω is equal to $\Delta\omega$. In the first part of the article, the author gives a comprehensive theoretical analysis of his circuit. For a given frequency range of the shift-generator, taking into account the possible absolute instability $\Delta\omega_0'$ of the synchronized generator (the synchronized generator frequency having to be fixed in the center of the retuning range), he develops, a formula giving the highest frequency Ω_1 at the output of the phase detector, at which the transmission factor of the filter (considered as ideal) must be equal to one.

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He also determines the requirements towards the frequency characteristic of the filter. The question of spurious components being very important, he uses, for his phase detector, such circuits as ensure the minimum output level of combination-frequencies. He finally reproduces a formula giving the index of spurious phase modulation and showing that this index can be reduced either by decreasing the transmission factor of the filter at the spurious frequency or by increasing the signal-to-interference ratio at the filter input, i.e., by using the most appropriate phase detector circuits (balancing circuits or ring-type circuits). In the last part of his article, the author gives a detailed connection diagram of the automatic phase control system in question. This diagram is accompanied by a short description of the principal component parts. The method of measuring the synchronization band and other measuring methods are also described. There are 7 figures, 1 table and 6 Soviet references.

SUBMITTED: May 14, 1960

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Automatic Phase Control as a Means of Obtaining a Highly Stable Regulated Frequency

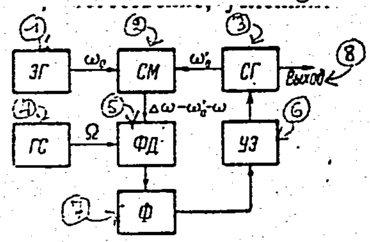

Рис. 1

Fig. 1: (1) - standard generator; (2) - mixer; (3) - synchronized generator; (4) - shift generator; (5) - phase detector; (6) - regulating cell; (7) - filter; (8) - Output.

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S/106/61/000/009/004/008
A055/A127

9,3274

AUTHOR: Shakhgil'dyan, V. V.

TITLE: Lock-in range in automatic phase control systems with an RLC-filter

PERIODICAL: Electrosvyaz', no. 9, 1961, 22 - 31

TEXT: The hold-in range and the lock-in range of the automatic phase control system are represented, respectively (Figure 2), by the synchronized generator detunings $\pm\Delta\omega_{hi}$ (at which synchronization is destroyed) and $\pm\Delta\omega_{l.i.}$ (at which synchronization is restored), stable synchronization conditions existing only (whatever be the initial conditions) within the lock-in range. After mentioning the defects of the automatic phase control systems with RC-filters, the author determines the stability conditions in the case of an automatic phase control system with an RLC-filter and finds the dependence of the lock-in range of this system on the filter parameters (in the case of a cosinusoidal characteristic of the phase detector). The differential equation in "operator form" ("v operatornoy forme") of the automatic phase control system with any filter-type connected after the phase detector can be written as follows [Ref. 2: Ka-

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Lock-in range in S/106/61/000/009/004/008
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pranov, M.V., "Fazovaya avtopodstroyka" (Automatic Phase Control) Candidate's dissertation. MEI. 1957.]:

$$p\varphi + \Delta\omega_{h.i.}\, k(p)\, F(\varphi) = \Delta\omega \qquad (1)$$

where φ is the phase difference of the synchronized and the standard generator oscillations; k(p) is the filter transmission factor in "operator form"; $\Delta\omega$ is the detuning of the synchronized generator with respect to the standard generator (with open automatic phase control system); $F(\varphi)$ is the phase detector characteristic, so normalized that its maximum value should be $|F(\varphi)| = 1$. The characteristic of the reactance tube is supposed to be linear. When the phase detector characteristic is cosinusoidal:

$$F(\varphi) = \cos\varphi \quad . \qquad (2)$$

For the RLC-filter shown in Figure 4:

$$K(p) = \frac{1}{\frac{p^2}{\omega_0^2} + d\frac{p}{\omega_0} + 1} \qquad (3)$$

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Lock-in range in .....

where $\omega_0 = \frac{1}{\sqrt{LC}}$ is the filter naturel frequency

and $d = \frac{R}{\omega_0 L}$ is the filter attenuation.

Substituting (2) and (3) in (1) and introducing the expressions:

$$\tau = \omega_0 t, \qquad \gamma = \frac{\Delta\omega}{\Delta\omega_{h.i.}} \qquad \text{and } k = \frac{\Delta\omega_{h.i.}}{\omega_0},$$

the author obtains:

$$\frac{\varphi'''}{k} + \frac{d}{k}\varphi'' + \frac{1}{k}\varphi' + \cos\varphi = \gamma, \tag{5}$$

i.e., the basic equation for the analysis of the stability of stationary conditions of the automatic phase control system. The condition $\varphi = \varphi_0 =$ const. is that all the derivatives should be equal to zero in the equilibrium point:

$$\varphi_0''' = \varphi_0'' = \varphi_0' = 0, \tag{6}$$

The stationary phase difference φ_0 being given by: $\cos\varphi_0 = \gamma$. (7)

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Condition (6) is satisfied for two equilibrium points φ_{01} = arc cos γ and $\varphi_{02} = 2\pi$ - - arc cos γ. The analysis shows that only point φ_{01} corresponds to a stable equilibrium. It shows also that:

$$d > k \sin \varphi_{02} \quad . \tag{13}$$

Sin φ_{02}, characterizing the steepness of the phase detector characteristic in the stable equilibrium point, can take any value between 0 and 1 (depending on γ). Satisfying (13) is particularly difficult when sin φ_{02} = 1. In this case:

$$d > k \tag{14}$$

In all other cases, a margin of stability will be ensured if inequality (14) is satisfied. If (14) is not satisfied, self-excitation of the automatic phase control system will take place. To determine the dependence of the automatic phase control system lock-in range on the filter parameters, it would be necessary to integrate (5), which cannot be done, in the general case, by analytical methods. The author resorts therefore to graphical analysis. The cosine function being a periodical function, the analysis of (5) can be limited to the representation, in the three-dimensional phase space, of a process occurring when φ varies within 2π. The author obtains a set of space curves and selects one

of them, the examination of which will enable him to solve (5) (for certain initial conditions) and to determine the lock-in range. He plots then such characteristic curves for fixed values of d and k, and for different values of the detuning γ ($\gamma_1 > \gamma_{lock-in}$, $\gamma_2 < \gamma_{lock-in}$ and $\gamma_3 = \gamma_{lock-in}$). These curves (an electronic computer being used for calculations) enable him to determine $\gamma_{lock-in}$ for different magnitudes of d and k.. Here are some of the obtained values of $\gamma_{lock-in}$:

	k = 0.45	k = 0.9	k = 1.5
d = 1	1	0.89	0.63
d = 2	0.97	0.84	0.615
d = 5	0.78	0.55	0.5
d = 10	0.62	0.44	0.38
d = 40	0.35	0.28	0.245

Experimental checks proved that these values are correct to within 7 - 8 %. There are 11 figures, 2 tables, 5 Soviet-bloc and 1 non-Soviet-bloc references. The reference to the English language publication reads as follows: Bailey, The

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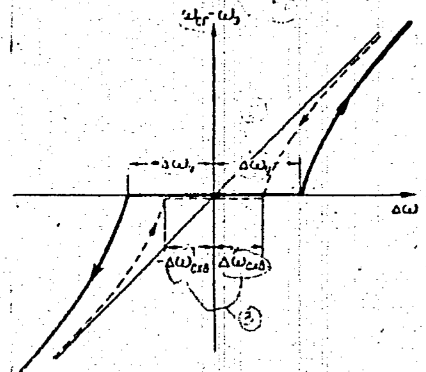
Lock-in range in ....

graphical solution of ordinary differential equations. "Philosophical Magazine", 1938, s.7, vol. 26, no. 173.

SUBMITTED: May 3, 1961.

[Abstracter's note: The following subscripts are translated in formulae and text: l.i. (lock-in) stands for захв; h.i. (hold-in) stands for у (uderzhaniye).]

Figure 2:
1 - $\omega_{synch.gen.} - \omega_{stand.gen.}$
2 - $\Delta\omega_{h.i.}$
3 - $\Delta\omega_{l.i.}$



Card 6/6

SHAKHGUL'DYAN, V.V.

Filtration of fluctuating interferences by the automatic phase frequency trim system with different filter possibilities. Radiotekhnika 16 no.10:28-37 O '61. (MIRA 14:10)

1. Deystvitel'nyy chlen Nauchno-tekhnicheskogo obshchestva radiotekhniki i elektrosvyazi imeni Popova.
(Frequency regulation) (Radiofilters) (Television)

32953
S/106/62/000/001/004/009
A055/A101

9,3274 (1040,1159)

AUTHOR: Shakhgil'dyan, V.V.

TITLE: Filter discrimination of discrete interferences by the system of phase automatic frequency trimming with an RLC-filter

PERIODICAL: Elektrosvyaz', no. 1, 1962, 34 - 39

TEXT: The purpose of the author is to show the advantage of using RLC-filters for the filter discrimination of interferences in the phase automatic frequency trimming systems. The filtering properties of these systems can be estimated by the ratio of the phase variations of the stabilized and the standard oscillator:

$$W(p) = \frac{\Delta\varphi \text{ stab. osc.}}{\Delta\varphi \text{ stand. osc.}} \quad (1)$$

(see the author's earlier article in Elektrosvyaz', no. 9, 1961). Under the following assumptions: 1) the effect of the interferences manifests itself by the appearance of an amplitude-phase modulation of the standard signal; 2) at a sufficient signal power-to-interference power ratio, the interference power has no effect on the phase detector characteristic; 3) amplitude modulation is sup-

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pressed in the preceding limiter stages, and 4) the reactance tube characteristic is linear, W (p) can be expressed (in operator form) as follows:

$$W(p) = \frac{1}{1 + \frac{p\tau}{K(p)}}, \tag{2}$$

where K (p) is the filter transmission factor at the phase detector output, and

$$\tau = \frac{1}{\Delta\omega_y |F'(\varphi_0)|}, \tag{3}$$

$\Delta\omega_y$ being the attenuation band of the system and $F'(\varphi_0)$ the transconductance of the normalized characteristic of the phase detector in the stable equilibrium point. In the worst possible case, i.e., when the transconductance of the normalized phase detector characteristic is equal to unity, the author obtains

$$|W(i\varepsilon)| = \frac{1}{\sqrt{(1 - kd\varepsilon)^2 + \varepsilon(1 - k^2\varepsilon)^2}}, \tag{9}$$

where $k = \frac{\Delta\omega_y}{\omega_0}$. With the aid of (9), he examines then the dependence of $|W(i\varepsilon)|$ on d and k. The results of this examination are grouped in tables where is shown the dependence of $|W(i\varepsilon)|$ on ε for several values of d (k =

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const.) and for several values of k (d = const.). The analysis of these tables and of the corresponding graphs reveals that, for given values of the relative "trap band" (polosa zakhvata) γ_{trap} of the examined system, the filter discrimination of the system with an RLC-filter depends but little on k and d when ε varies between 1 and 4, provided that a sufficient stability margin is ensured in the system. The author next examines briefly the case of a system with an RC-filter and draws the following conclusions: The use of an RLC-filter permits (for a given γ_{trap}) to increase the filter discrimination at high frequencies. This increase grows with the frequency of the interference. At ε = 100, it reaches about 5/1. On the other hand, the use of RLC-filters in phase automatic frequency trimming systems is not expedient in the case of low-frequency interferences. An experimental check confirmed the theoretical conclusions. There are 6 figures, 4 tables, and 3 references: 2 Soviet-bloc and 1 non-Soviet-bloc. The Soviet personalities mentioned in the article are: M.V. Kapranov.

SUBMITTED: May 3, 1961

L 10488-63
ACCESSION NR: AP3000530 S/0106/63/000/005/0009/0014

45

AUTHOR: Shakhgil'dyan, V. V.

TITLE: A method of filtration of external discrete noise in a phase AFC system

SOURCE: Elektrosvyaz', no. 5, 1963, 9-14

TOPIC TAGS: external discrete noise, filtration, phase AFC system, parasitic FM, amplitude-detector channel, noise suppression

ABSTRACT: The highly efficient filtering of external discrete noise whose frequency is very close to that of a standard signal through the use of a modification of the phase AFC system is described. It is assumed that synchronization of the system has been achieved and that the standard signal is subjected to amplitude and phase modulation by the noise. When noise and signal frequencies are very close, the parasitic FM of the signal is not suppressed by the usual phase AFC. However, the suppression of this type of noise can be achieved by the introduction of an amplitude-detector channel to the phase AFC system (see Fig. 1 of Enclosure). To check this theory a circuit was built consisting of a synchronized

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generator, buffer stage, ring phase detector, reactance tube, and linear amplifier. One GSS6-I signal generator was used as a source of standard frequency oscillations. A second generator introduced discrete noise to the amplifier input. The experiment was carried out at 1100 kc, with noise detuned by 5 kc, and with a signal-to-noise ratio of 5. The band was about ± 15 kc. Under these conditions, noise suppression of 30—40 db was achieved without affecting the pull-in bands. It is concluded that the circuitry described is an efficient means of suppressing noise too close to the signal frequency to be handled by the usual phase AFC circuitry. Orig. art. has: 15 formulas and 3 figures.

ASSOCIATION: none

SUBMITTED: 12Jun62 DATE ACQ: 03Jun63 ENCL: 01

SUB CODE: SD NO REF SOV: 003 OTHER: 001

Card 2/2

SHAKHGIL'DYAN, V.V.; LYAKHOVKIN, A.A.

Letter to the editors on P.V.Bernshtein's article "Filtration of white noise in precise frequency receivers." Elektrosviaz' 17 no.12:42 D '63. (MIRA 17:2)

SHAKHGIL'DYAN, V.V.

Determination of the holding band in a phase-type automatic frequency control system. Trudy ucheb. inst. svíazi no.14: 77-84 '63. (MIRA 17:9)

1. Moskovskiy elektrotekhnicheskiy institut svyazi.

TERENT'YEV, B.P.; SHAKHGIL'DYAN, V.V.; LYAKHOVKIN, A.A.

Synchronous multichannel radio communication station. Trudy ucheb. inst. sviazi no.14:93-98 '63. (MIRA 17:9)

1. Moskovskiy elektrotekhnicheskiy institut svyazi.

ACCESSION NR: AP4026149 S/0108/64/019/003/0042/0047

AUTHOR: Shakhgil'dyan, V. V. (Active member)

TITLE: Filtration of discrete noise in a nonlinear phase AFC system

SOURCE: Radiotekhnika, v. 19, no. 3, 1964, 42-47

TOPIC TAGS: AFC, phase AFC, noise, discrete noise, nonlinear phase AFC, discrete noise filtration

ABSTRACT: Recently published works have treated noise filtration with a linear approximation of the phase-detector characteristic. This simplification is only valid for low noise levels and neglects the effect of noise on the mean value of the phase difference between the received and the reference signals. The present article tries to theoretically determine the effect of the nonlinearity of the phase-detector characteristic on the filter discrimination of the phase AFC system. Assumptions made are: (a) a phase-modulated reference signal and (b) the